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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Docket No. BON-104

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WASHINGTON, D.C. 20231

Sir:

Transmitted herewith for filing is the patent application of:

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STEPHEN E. KEELEY
JAMES H. KUNDINGER

For: TWIN SHEET THERMOFORMER

Enclosed are:

- Four sheets of drawings in triplicate (informal)
 An assignment of the invention to:
 Certificate of Express Mailing
 Information Disclosure Statement by Applicant (and patent copies)
 Certified copy of a _____ application
 An associate Power of Attorney
 Combined Declaration and Power of Attorney

The filing has been calculated as shown below:

FOR	NO. FILED	NO EXTRA	RATE	TOTAL
BASIC FEE				\$ 790.00
TOTAL CLAIMS	12	- 20 =	0	X \$ 22.00
INDEPENDENT CLAIMS	2	- 3 =	0	X \$ 82.00
[] MULTIPLE DEPENDENT CLAIMS			+ \$270.00	\$ --
RECORDING OF ASSIGNMENT			+ \$ 40.00	\$ --
			TOTAL	\$ 790.00

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- Any patent application processing fees under 37 CFR 1.17.
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 Any filing fees under 37 CFR 1.16 for presentation of extra claims.
 Any deficiency in the filing fee.

Date: October 1, 1997

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TWIN SHEET THERMOFORMER

1 BACKGROUND OF THE INVENTION

2 This invention concerns thermoforming apparatus and more
3 particularly apparatus for forming two preheated sheets of plastic
4 into separate part halves in separate upper and lower molds, the
5 part halves subsequently having their edges sealed together by
6 pressing the upper and lower molds together to form a single
7 unitary part.

8 Such twin sheet thermoforming apparatus and methods have
9 heretofore been developed to produce such parts as automotive fuel
10 tanks, etc.

11 The upper and lower molds are installed in respective upper
12 and lower platens which are driven apart to separate the molds
13 sufficiently to allow unloading the completed parts.

14 U. S. Patent No. 3,925,140, issued on December 9, 1975
15 describes such apparatus.

16 The means for forcing one mold against the other to fuse the
17 part seam has involved the use of a series of inflatable tubes or
18 bags disposed beneath the lower mold.

19 After the upper and lower platens are locked together using
20 locking shafts engaged by selectively engaged couplings, the
21 inflatable tubes or bags are inflated, lifting the lower mold to be
22 pressed against the upper mold causing the part half perimeters to
23 be fused together.

24 This arrangement is shown in U. S. Patent No. 3,925,140,
25 issued on December 9, 1975.

26 The use of inflatable bags or tubes is effective to apply a
27 fusing pressure but results in an imperfect uniformity of the seam
28 and the final size of the part, since the extent of squeezing may
29 not be completely uniform as there is no positive control over the
30 movement of the mold.

31 It has been proposed to utilize hydraulic cylinders to squeeze
32 the molds together to improve the uniformity of the seam. However,
33 even with the hydraulic cylinders, the travel of each cylinder must

1 be precisely uniform in order to achieve the end result of uniform
2 squeezing of the seam perimeter. Precision assembly of the
3 components is required in order to accomplish this result. Even
4 so, the temperature of the plastic material may vary slightly such
5 that slightly different travel may occur from different squeezing
6 resistance, the end result also being a nonuniform seam.

7 As noted, such twin sheet thermoforming apparatus have sets of
8 platen locking shafts carried by the upper and lower platens, which
9 shafts are coupled together when the mold parts are squeezed
10 together. These shafts have each been threaded to a nut component
11 which controls the relative position of the mold parts when the
12 platens are locked together at the initiation of the squeeze cycle,
13 thus predetermining the final seam thickness and part size after
14 the maximum travel of the cylinders has been reached.

15 To adjust the apparatus such that a different part can be
16 accommodated, it is necessary to adjust the position of each
17 locking shaft. A considerable variation in the depth of the molds
18 can occur for various parts formed by such apparatus. This is a
19 tedious and time consuming task since the adjustments must be
20 uniformly carried out for all of the four shafts usually employed
21 in each set.

22 Accordingly, it is an object of the present invention to
23 provide a twin sheet thermoformer of the type described in which
24 uniform squeezing of the mold parts is achieved in a simple,
25 relatively low cost manner.

26 It is another object of the present invention to provide such
27 apparatus in which uniform adjustments of the locking shafts may be
28 made quickly and accurately.

29 **SUMMARY OF THE INVENTION**

30 These and other objects of the present invention, which will
31 be understood upon a reading of the following specification and
32 claims, are achieved by arranging hydraulic cylinders to carry out
33 a pulling action on the platen locking shafts, arranged to create
34 a positively limited relative travel of the molds in being pulled

1 towards each other.

2 The fluid flow to each cylinder is controlled by routing the
3 hydraulic fluid through a flow divider such that uniform travel of
4 each cylinder piston is insured during the squeezing process,
5 resulting in a uniform depth seam being formed.

6 The locking shafts on the upper platen are threaded and each
7 are received in a rotatable nut component having a chain sprocket
8 fixedly attached. A driven recirculating chain engages each
9 sprocket nut such that simultaneous rotation of all of the sprocket
10 nuts occurs to precisely execute a uniform simultaneous adjustment
11 of all of the locking shafts on the upper platen. This enables a
12 rapid yet precise adjustment of the relative position of the
13 platens when they are locked together for a given part application.

14 **DESCRIPTION OF THE DRAWINGS**

15 Figure 1 is a side elevational view of the thermoformer mold-
16 platen apparatus according to the present invention.

17 Figure 2 is an end elevational view of the apparatus shown in
18 Figure 1.

19 Figure 3 is a plan view of the apparatus shown in Figures 1
20 and 2.

21 Figure 4 is a schematic diagram of the four hydraulic
22 cylinders and the flow divider associated therewith according to
23 the present invention.

24 Figure 5 is a side elevational view of the upper platen with
25 the connecting shafts and chain-sprocket-nut adjustment mechanism.

26 Figure 6 is an enlarged partially sectional view of a
27 sprocket-nut shown in Figure 5.

28 **DETAILED DESCRIPTION**

29 In the following detailed description, certain specific
30 terminology will be employed for the sake of clarity and a
31 particular embodiment described in accordance with the requirements
32 of 35 USC 112, but it is to be understood that the same is not
33 intended to be limiting and should not be so construed inasmuch as

1 the invention is capable of taking many forms and variations within
2 the scope of the appended claims.

3 Referring to Figure 1, the thermoformer apparatus 10 according
4 to the present invention is shown without certain conventional
5 portions thereof, such as the heating oven, part handling
6 mechanisms, etc. in the interests of clarity, as they do not form
7 a part of the present invention and are well known to those skilled
8 in the art.

9 The apparatus 10 includes an upper platen 12 and a lower
10 platen 14 each drivably movable up and down within a machine frame,
11 portions 16 shown in Figure 1.

12 The upper and lower platens 12, 14 are each supported on
13 respective sets of four gear rack support posts 18A, 18B, the
14 platens 12, 14 adapted to be driven up and down on the posts 18A,
15 18B, respectively, to thereby be positioned closer or further
16 apart. A drive system for this purpose comprises platen
17 positioning means which includes respective electric drive motors
18 20A, 20B each driving sets of cross shafts 22A, 22B and 24A, 24B
19 via drive belts 26 and pulleys 28.

20 The cross shafts 22A, 22B, 24A, 24B each have a pinion gear 30
21 at each end engaging a respective one of the gear racks machined
22 into the vertical support posts 18A, 18B.

23 A conventional servo control system is used to control the
24 motors 20A, 20B to drive the upper and lower platens 12, 14 to a
25 predetermined location.

26 A disc brake 32A, 32B is used to hold the platens 12, 14 in a
27 selected vertical position on the posts 18A, 18B.

28 The sides of the upper platen 12 carry a first set of
29 vertically extending locking shafts, comprised of pairs of threaded
30 locking shafts 34A, 34B on sets of plates 36 welded to each side of
31 the upper platen 12, reinforcing gussets 38 and shaft guide plates
32 40 also provided welded to the side of the upper platen 12 (Figure
33 6).

34 Each of the threaded locking shafts 34A, 34B are threadably
35 engaged by being received in nut members 42 disposed over a

1 respective plate 36 and resting on a rotary bearing 44 (Figure 6).
2

3 Hold-down rollers 46 engage a flange 48 so as to prevent the
4 nut members 42 from advancing upwardly on threaded shaft 34A or 34B
when rotated.

5 The four nut members 42 are able to all be simultaneously
6 rotated by means of a recirculating chain 50 engaging a sprocket 52
7 fixed to each nut member 42. Suitable idler guide sprockets are
8 provided as shown.

9 The chain 50 is driven by an electric motor 54 and right angle
10 drive 56 rotating a drive sprocket 58 engaging the chain 50.

11 A bar 60 is fixed across the tops of each pair of threaded
12 locking shafts 34A, 34B to prevent their rotation. Thus, the
13 shafts 34A, 34B are simultaneously rotated when the chain 50 is
14 driven.

15 This allows adjustment of the relative vertical position of
16 the shafts 34A, 34B on the upper platen 12.

17 The bottom of each locking shaft 34A, 34B carries a fluid
18 pressure operated coupling mechanism 62 of a well known
19 commercially available type, such as from Locking Cylinder
20 Technologies, Inc. of Racine, Wisconsin. The coupling mechanisms
21 62 are each aligned with a respective one of a second set of
22 vertical locking shafts, comprised of pairs of hydraulic cylinder
23 shafts 64 projecting upwardly from each side of the lower platen
24 14. The shafts 64 each have a locking bolt 66 secured to its end
25 adapted to be selectively locked in the aligned coupling mechanism
26 62 when mechanisms 62 are activated.

27 The cylinder shafts 64 project upwardly from an associated
28 short stroke hydraulic cylinder 68 secured to a plate 70 welded to
29 a pair of gussets 72, in turn welded to a side of the lower platen
30 14.

31 The cylinder shafts 64 are each guided by passing through a
32 bushing in an upwardly spaced plate 74 as shown.

33 The hydraulic cylinders 68 are of a short stroke high force
34 type, with large forces generated to produce the squeezing of the
35 part rim (not shown). The cylinders 68 preferably are stroked

1 against a fixed stop, as by bottoming of the piston 69 (Figure 4)
2 against the cylinder endwalls to be positively located when the
3 upper platen 12 and lower platen 14 are fully drawn together. This
4 insures an accurately sized part.

5 A position encoder 76 generates a control signal corresponding
6 to the travel of the shafts 64.

7 In order to insure precise uniformity of travel of the
8 cylinder shafts 64, hydraulic fluid under pressure is routed
9 through a flow divider 78 (Figure 4). The flow divider 78 is a
10 commercially available device (Delta HPR 23-59) resembling a
11 multiple rotor, positive displacement gear motor. Hydraulic fluid
12 to one of the cylinders 68 is routed through one of the rotors R_1
13 causing it to be rotated. The remaining rotors R_2-R_4 are connected
14 to be rotated in unison therewith. The hydraulic fluid is gated
15 via these other rotors R_2-R_4 to the other three cylinders 64. This
16 establishes uniform flow to and thus displacement of each cylinder
17 68.

18 In operation, the upper and lower platens are driven to be
19 located properly by motors 20A, 20B to allow heated sheets to be
20 introduced between the molds M_U , M_L . A conventional thermoforming
21 process is carried out in each mold M_U , M_L to form each part half
22 with a flange extending over the outer perimeter of the respective
23 mold faces, in the well known manner.

24 The molds M_U , M_L are brought nearly together, the shafts 64
25 thereby advanced to be inserted into the coupling mechanisms 62,
26 which are activated to lock the upper platen 12 to the lower platen
27 14.

28 Thereafter, the cylinders 68 are pressurized so as to cause
29 the cylinder shafts 64 to be pulled down to draw the molds M_U , M_L
30 together, squeezing the part rims together, forming a part seam of
31 a uniform thickness when the cylinders are fully stroked, this
32 stroking proceeding uniformly due to the action of the flow divider
33 78.

34 During this time, the upper platen 12 is held by the brakes
35 32A while the brakes 32 associated with the lower platen 14 are

1 released.

2 However, the motor 20B is driven by application of the signal
3 from the rotary encoder 76 to the motor servo control 80 so as to
4 cause the lower platen 14 to be driven by the motor 20B to cause
5 the lower platen 14 to "follow" the upward movement of the lower
6 platen 14 caused by the action of the hydraulic cylinders 64.

7 Thus, the weight of the lower platen 14 is supported by the
8 motor 20B to avoid being added to the weight supported by the
9 brakes holding the upper platen 12.

10 The platens 12, 14 are thereafter released through
11 deactivation of the coupling mechanisms 62 and release of the
12 brakes 32A to be able to be driven apart and allow the completed
13 part (not shown) to be removed.

14 In the event a different part is to be made, adjustments due
15 to the mold size differences are easily made by driving the chain
16 50 to relatively reposition the shafts 34A, 34B and the upper
17 platen 12 as necessary.

18 A manual operation of the chain drive is possible, as is an
19 automatic programmed powered drive of the chain 50 and nut members
20 42.

21 Accordingly, an improved apparatus is provided allowing more
22 accurately sized parts to be produced and allowing rapid and
23 accurate changeover of tooling for parts of different
24 configurations.

CLAIMS

1. A twin sheet thermoformer apparatus including:
- a frame;
 - an upper platen for mounting an upper thermoforming mold, said upper platen movable up and down on said frame through a range of positions thereof;
 - upper platen positioner means including platen drive means for selectively moving said upper platen to any position in said range of positions, said positioner means also including means for holding said upper platen stationary at positions within said range;
 - a lower platen for mounting a lower thermoforming mold on said frame, said lower platen positioned on said frame below said upper platen and movable up and down thereon towards and away from said upper platen through a range of positions;
 - lower platen positioning means including platen drive means for selectively moving said lower platen to any position in said range of positions, said positioning means also including means for holding said lower platen stationary at positions within said range;
 - a first set of vertical locking shafts mounted to said upper platen and a second set of vertical locking shafts mounted to said lower platen, each locking shaft in said second set aligned with a respective locking shaft in said first set;
 - coupling means operable to couple said first and second sets of locking shafts together after said upper and lower platen are moved together to a predetermined spacing therebetween;
 - adjustment means causing one of said first or second sets of locking shafts to be selectively adjusted so that said predetermined spacing between said upper and lower platen whereat said coupling means is operable is varied; and,
 - adjustment drive means for driving each of said adjustment means to cause simultaneous adjustment of said locking shafts in said one of said first or second sets, whereby uniform adjustment

of said predetermined spacing is carried out.

2. The apparatus according to claim 1 wherein each of said locking shafts in said one of said first or second sets of locking shafts is threaded and engages a respective nut member, each said nut member rotated by said drive means to carry out said adjustment.

3. The apparatus according to claim 2 wherein each said nut member is captured to prevent axial movement so that each locking shaft is advanced axially as nut members are rotated.

4. The apparatus according to claim 3 wherein said drive means includes a chain recirculated around each nut member, each nut member having a sprocket attached thereto engaged with said chain.

5. The apparatus according to claim 4 wherein said drive means includes a motor driving a drive sprocket to cause recirculation of said chain and simultaneous rotation of said nut members.

6. The apparatus according to claim 1 wherein said actuation means comprises a set of hydraulic cylinders each driving one of said second set of locking shafts to cause said lower platen and upper platen to be drawn together.

7. The apparatus according to claim 6 further including encoder means generating signals corresponding to the upward movement of said lower platen caused by operation of said hydraulic cylinders, said lower platen drive means responsive to said encoder signals to follow said upward movement of said lower platen to support the weight of said lower platen.

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8. A twin sheet thermoformer apparatus including:
a frame;

an upper platen for mounting an upper thermoforming mold, said upper platen movable up and down on said frame through a range of positions thereon;

upper platen positioner means including platen drive means for selectively moving said upper platen to any position in said range of positions, said positioner means also including means for holding said upper platen stationary at positions within said range;

a lower platen for mounting a lower thermoforming mold on said frame, said lower platen positioned on said frame below said upper platen and movable up and down thereon towards and away from said upper platen through a range of positions;

lower platen positioning means including platen drive means for selectively moving said lower platen to any position in said range of positions, said positioning means also including means for holding said lower platen stationary at positions within said range;

a first set of vertical locking shafts mounted to said upper platen and a second set of vertical locking shafts mounted to said lower platen, each locking shaft in said second set aligned with a respective locking shaft in said first set;

coupling means operable to couple said first and second sets of locking shafts together after said upper and lower platen are moved together to a predetermined spacing therebetween; and,

actuator means including a set of hydraulic cylinders, each hydraulic cylinder pulling one of said locking shafts in one of said first or second sets so as to draw said upper and lower platens together.

9. The apparatus according to claim 8 further including a flow divider means supplying each of said hydraulic cylinders so as to equalize flow to each hydraulic cylinder and insure uniform travel of all portions of said upper and lower platens towards each other.

10. The apparatus according to claim 8 further including means positively limiting the stroke of said hydraulic cylinders to positively limit the travel of said upper and lower platens toward each other by operation of said cylinders.

11. The apparatus according to claim 9 further including encoder means generating signals corresponding to the travel of said lower platen caused by operation of said hydraulic cylinders, said lower platen drive means responsive to said encoder signals to drive said lower platen correspondingly, whereby said platen drive means carries the weight of said lower platen.

12. The apparatus according to claim 9 wherein said flow divider comprises a series of positive displacement rotors coupled together, hydraulic flow to one cylinder caused to drive one rotor which drives the remaining rotors, the remaining rotors gating hydraulic flow to the remaining cylinders.

1 **ABSTRACT OF THE DISCLOSURE**

2 A twin sheet thermoformer apparatus using hydraulic cylinders
3 to draw the upper and lower platens together for uniform seam
4 forming of the part. A flow divider insures uniform travel of each
5 hydraulic cylinder. An adjustment mechanism enables simultaneous
6 adjustment of the position of four locking shafts on one platen
7 coupled to form locking shafts on the other platen preparatory to
8 operation of the hydraulic cylinders. The adjustment mechanism
9 includes nut members each threaded onto a locking shaft with a
10 recirculating chain engaged with a sprocket on each nut member.
11 Driving the chain enables simultaneous adjustment of each shaft to
12 allow the platen positions to be quickly and accurately adjusted.
13 An encoder generates signals corresponding to the lower platen
14 travel caused by operation of the hydraulic cylinders, which are
15 transmitted to the lower platen drive servo motor to drive the
16 lower platen correspondingly.

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that: My residence, post office address, and citizenship are as stated next to my name; and I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

TWIN SHEET THERMOFORMER

The specification of which
 is attached hereto
[] was filed on _____, as Application Serial No. _____.
[] and was amended on or through _____.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, 112, I acknowledge the duty of disclose material information as defined in Title 37, Code of Federal Regulations, 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of the application.

NONE
(application serial no.) (filing date) (status)

And I hereby appoint John R. Benefiel, Patent Office Registration No. 24,889, as my attorney, to prosecute this application and to transact all business in the United States Patent and Trademark Office connected therewith. Send all correspondence to: John R. Benefiel, 280 Daines Street, Suite 100 B, Birmingham, Michigan 48009, telephone no. 248-644-1455.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Inventor's signature _____

Date _____ Citizenship USA

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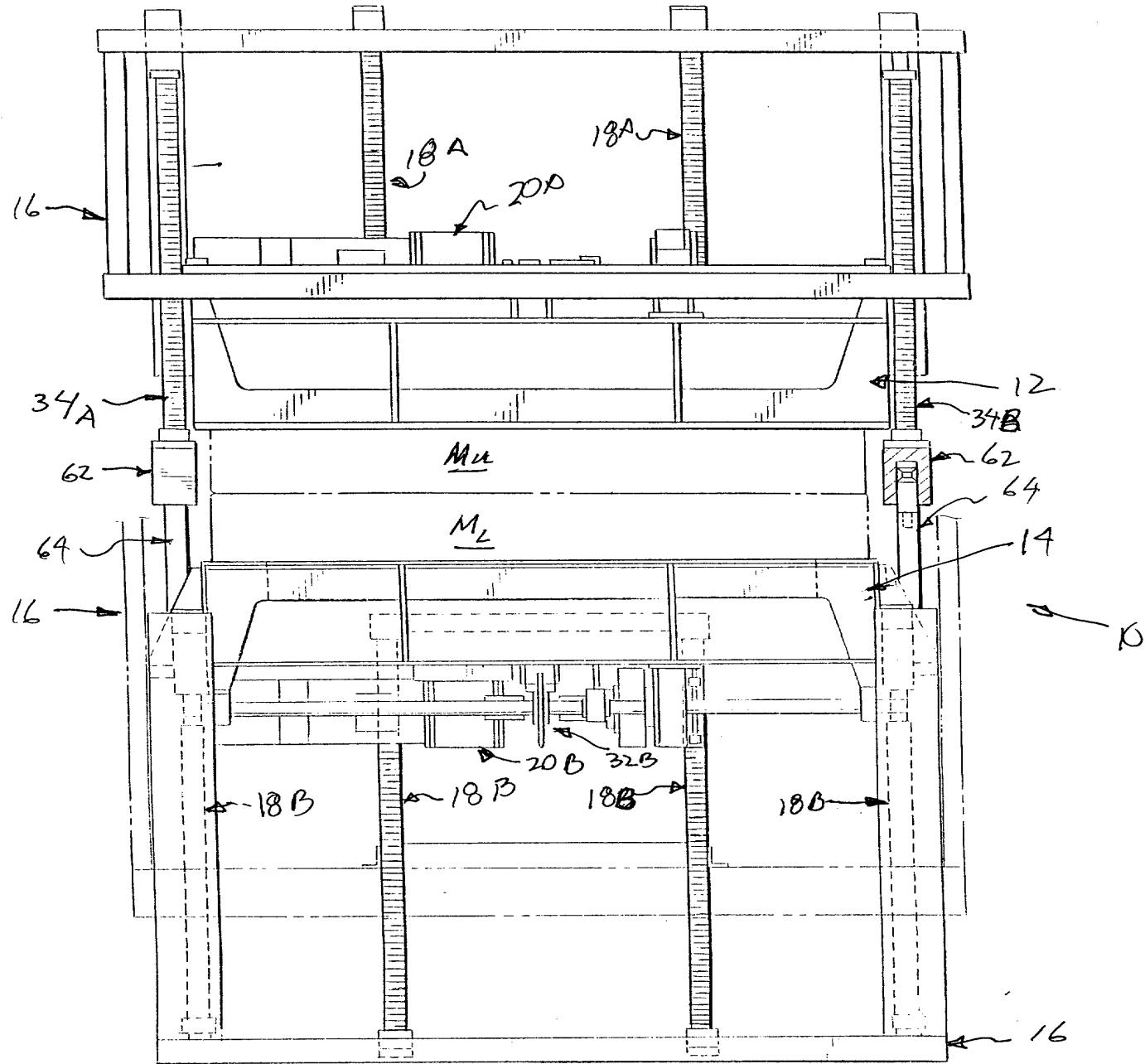


FIG - 1

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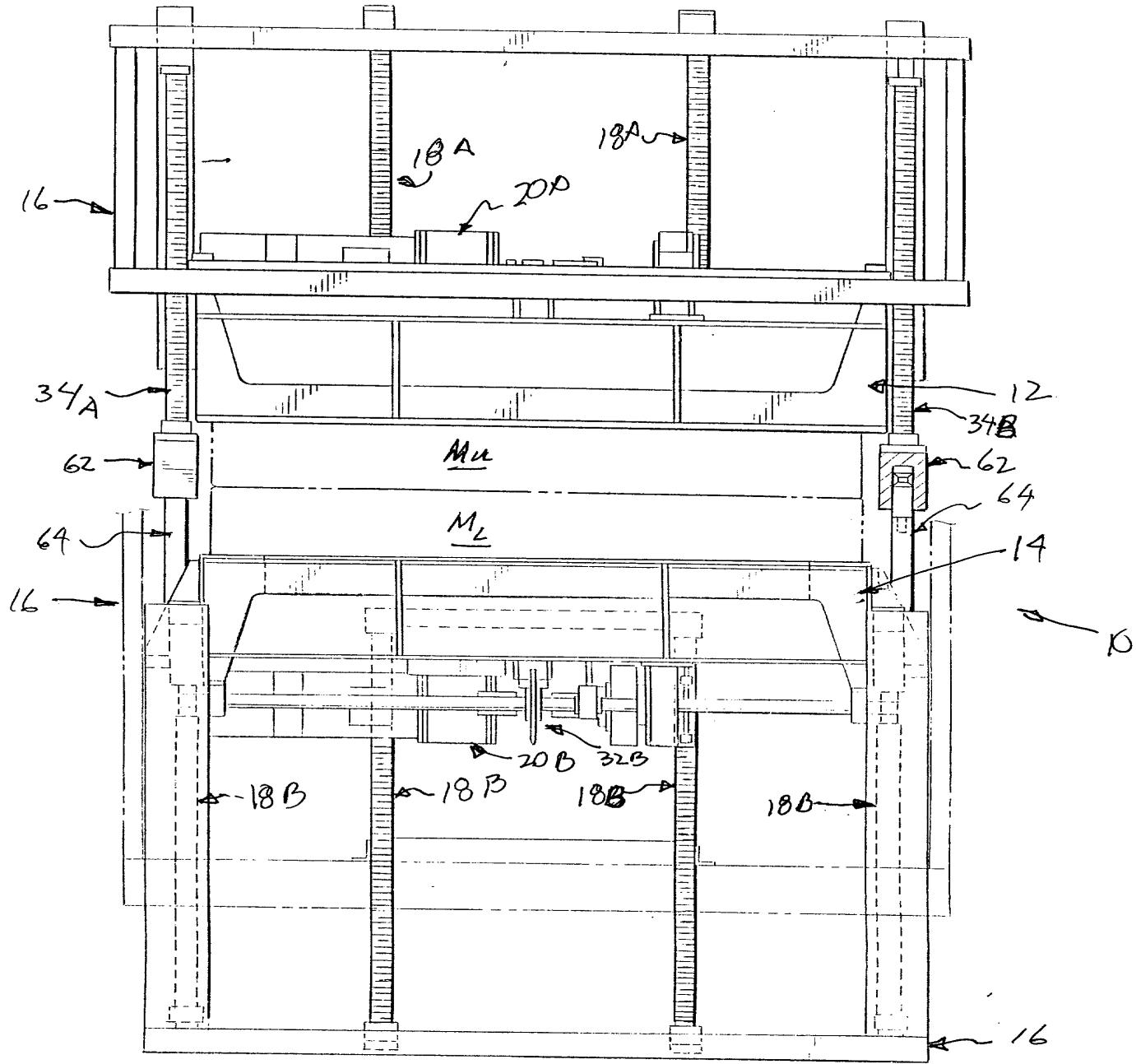


FIG - 1

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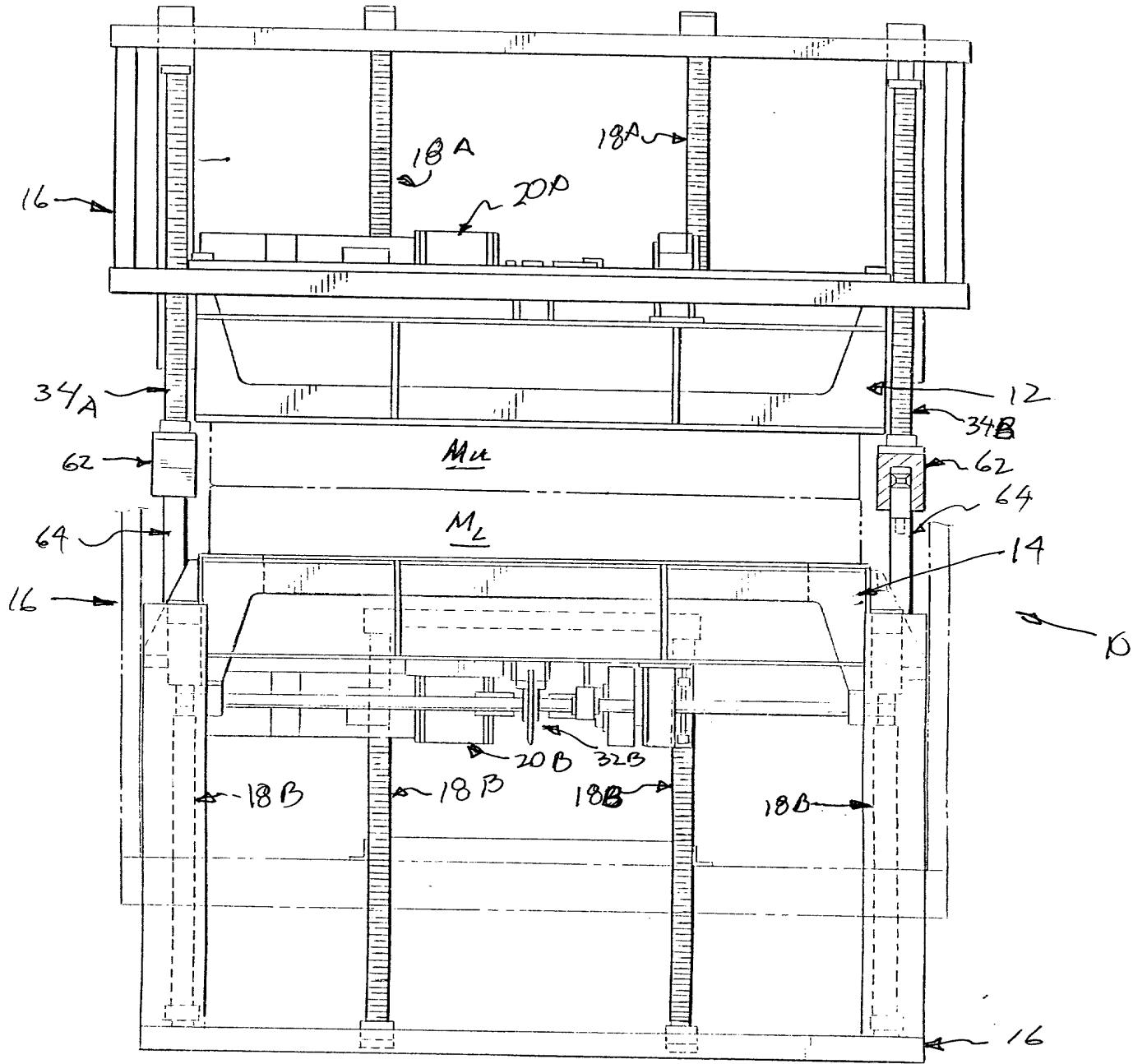


FIG - 1

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FIG - 2

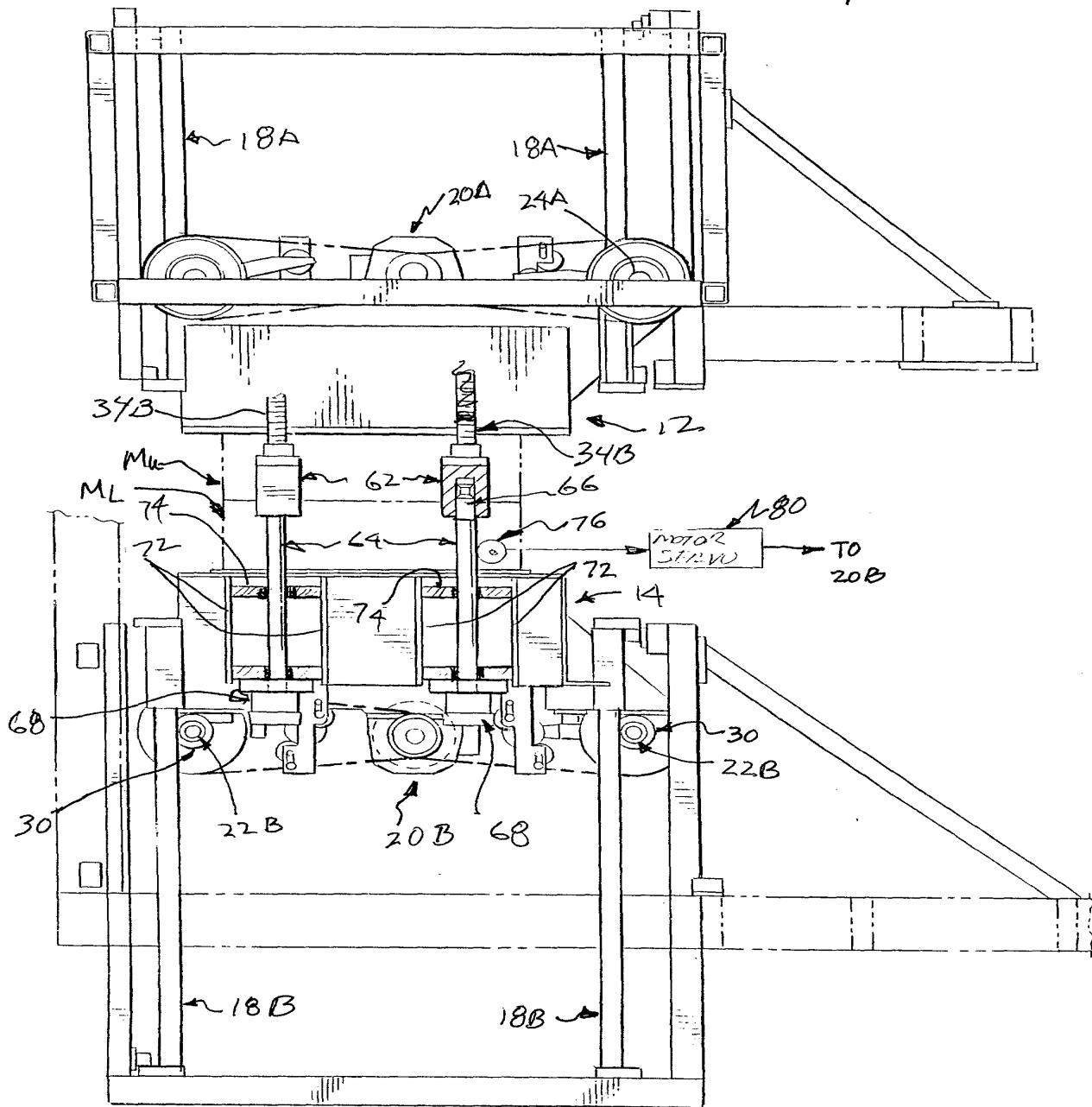


FIG-2

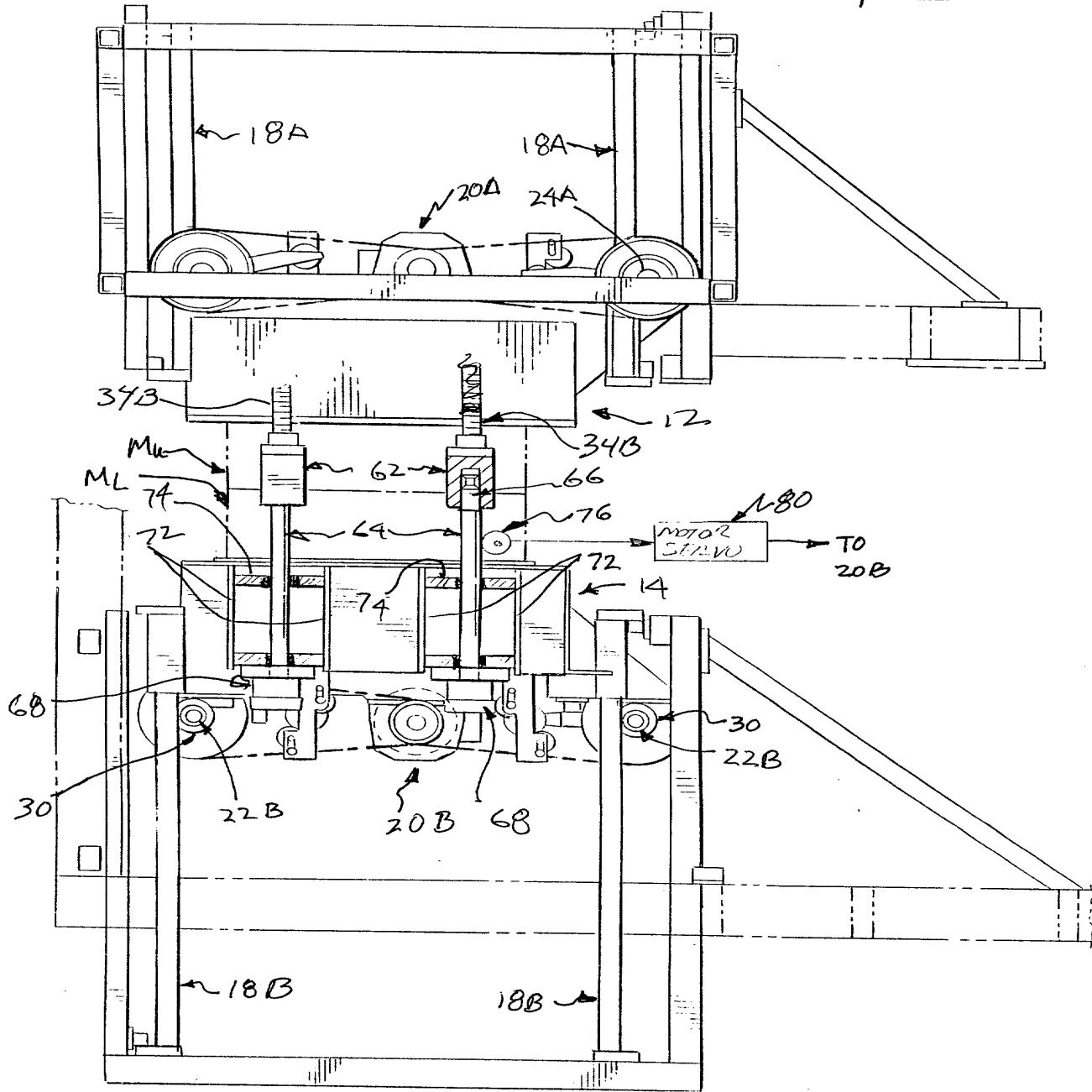
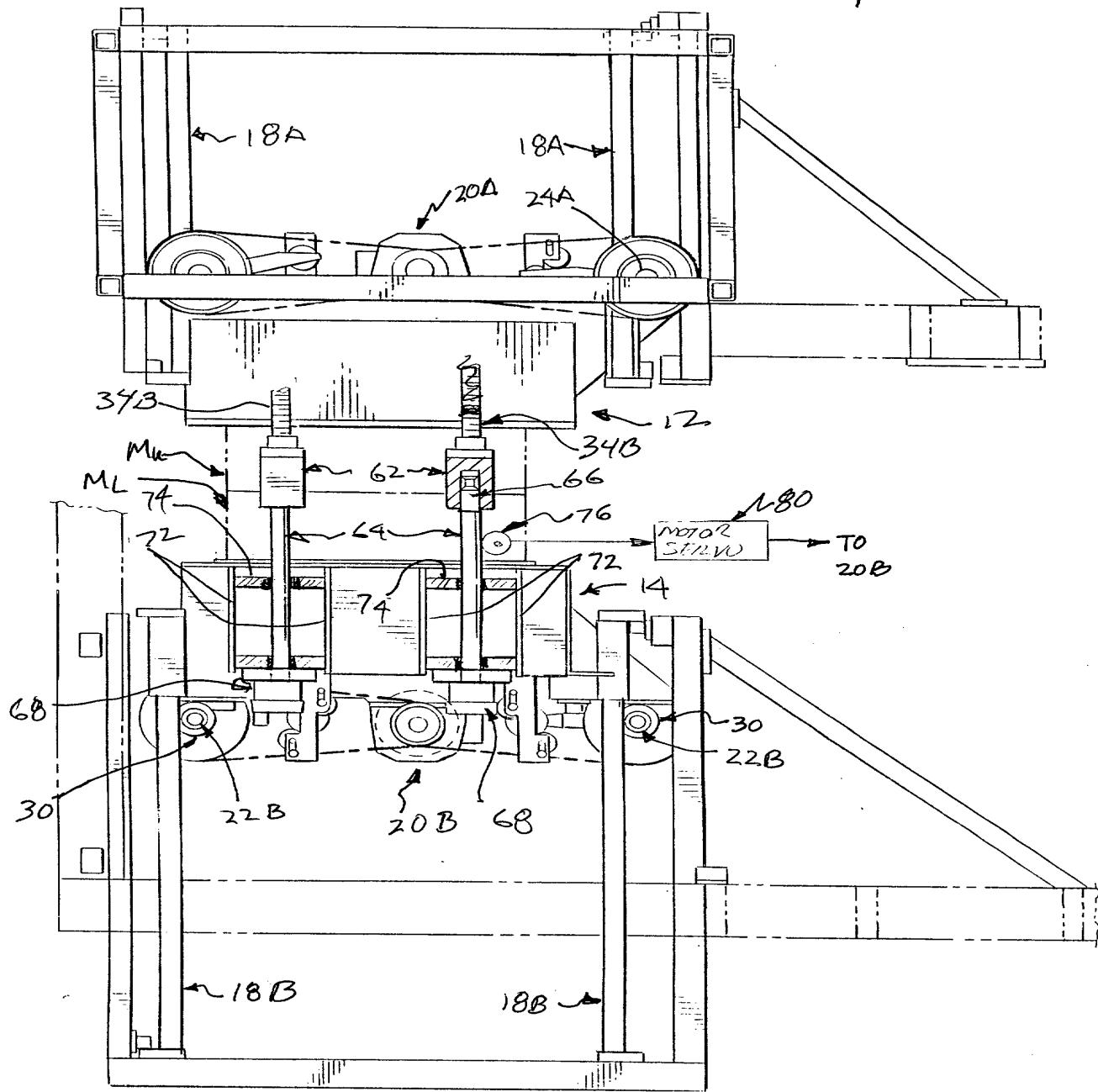


FIG-2



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FIG-3

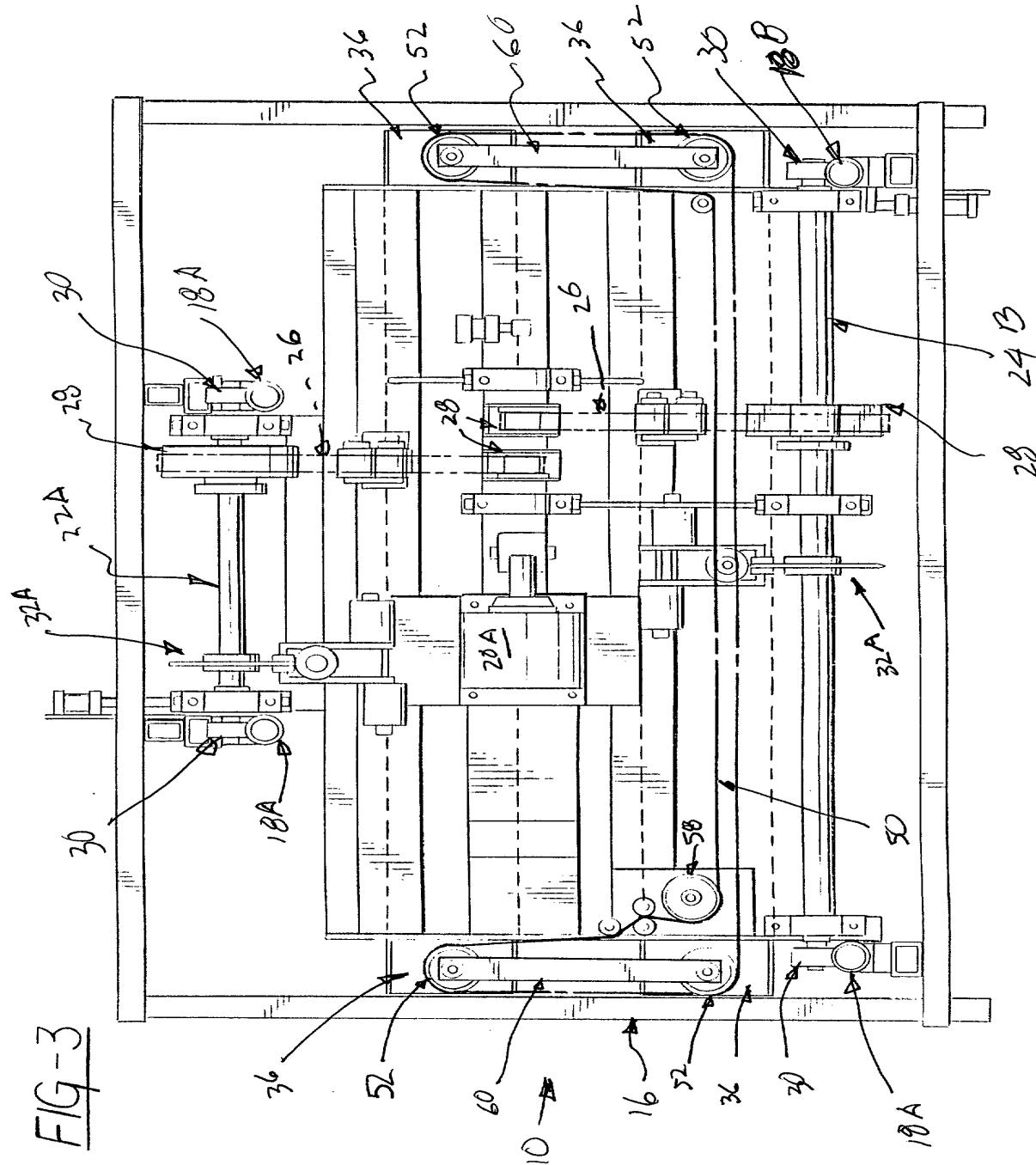


Fig-3

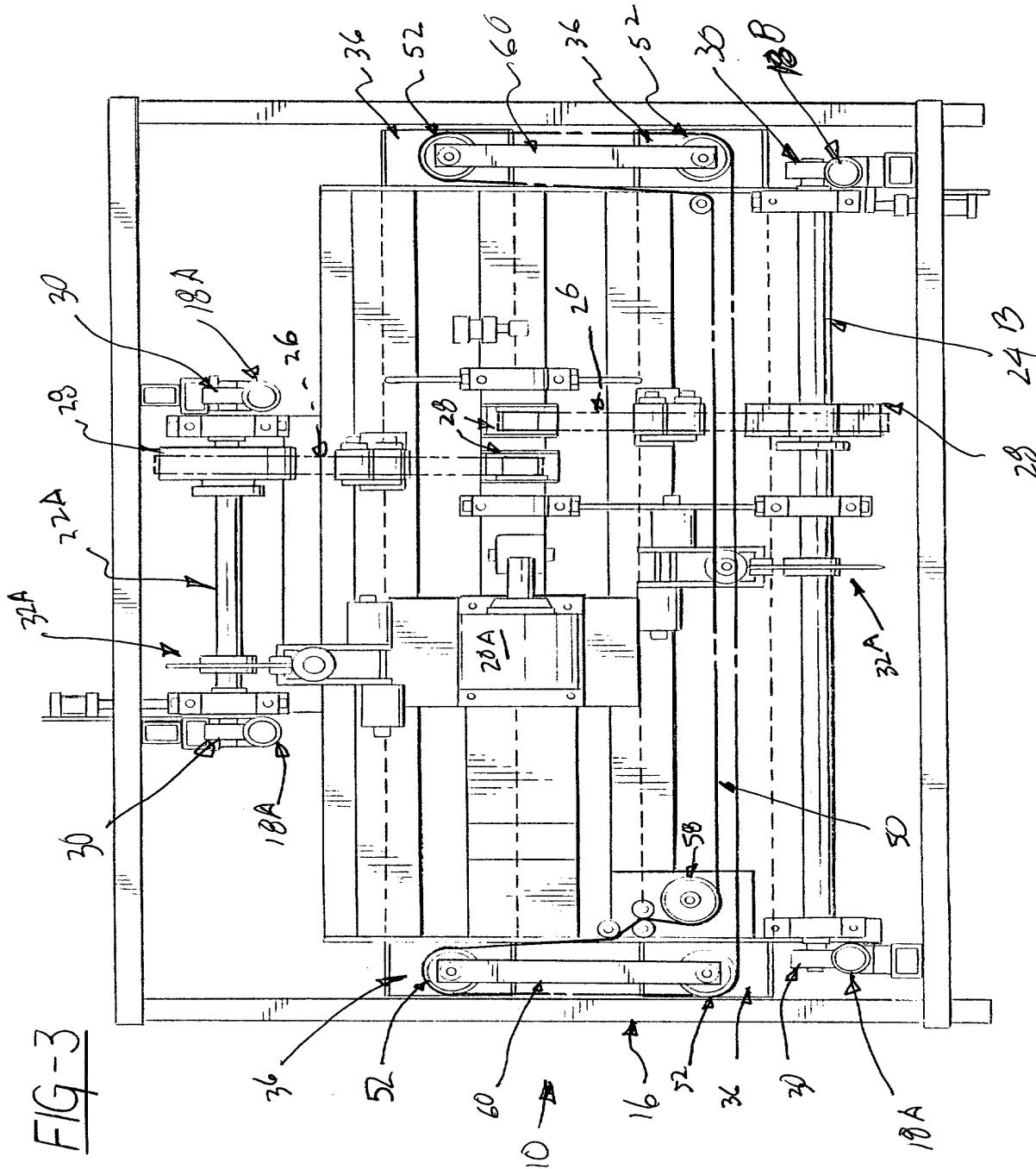
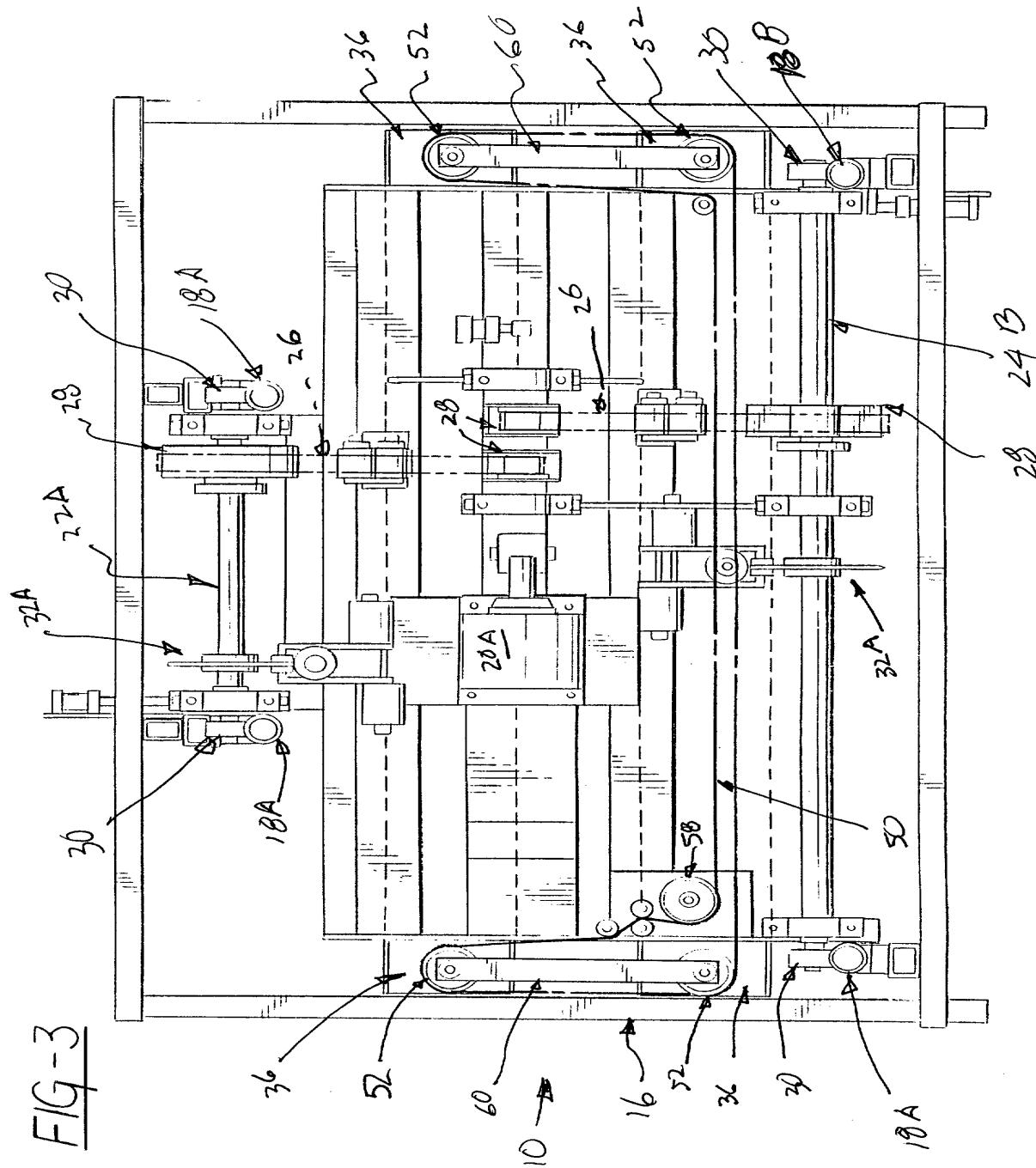
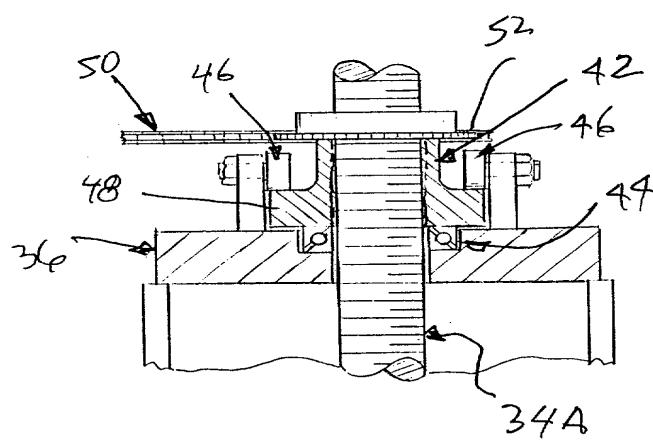
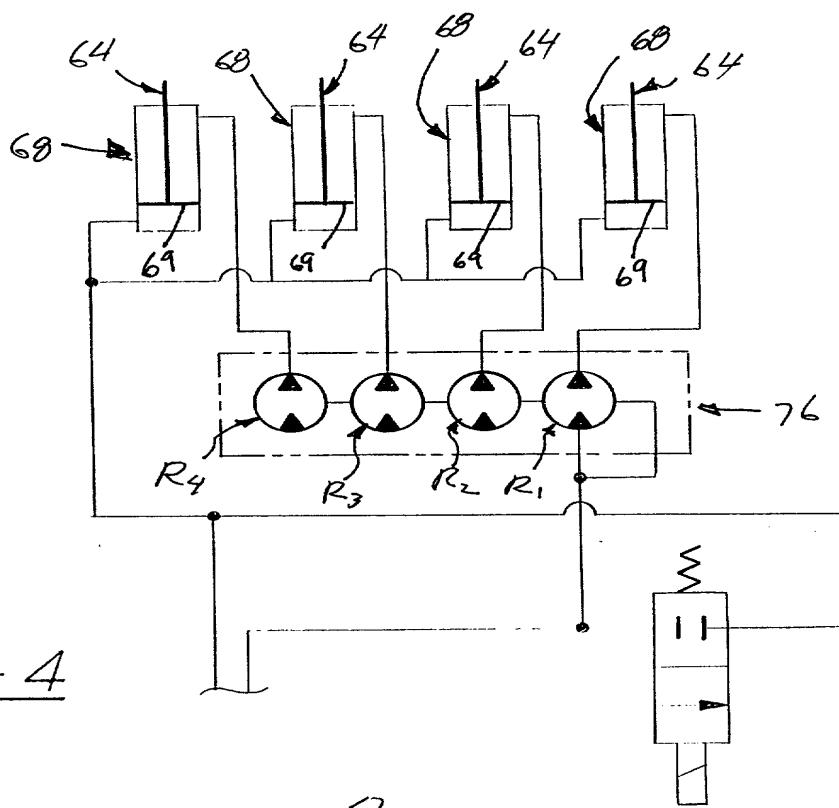
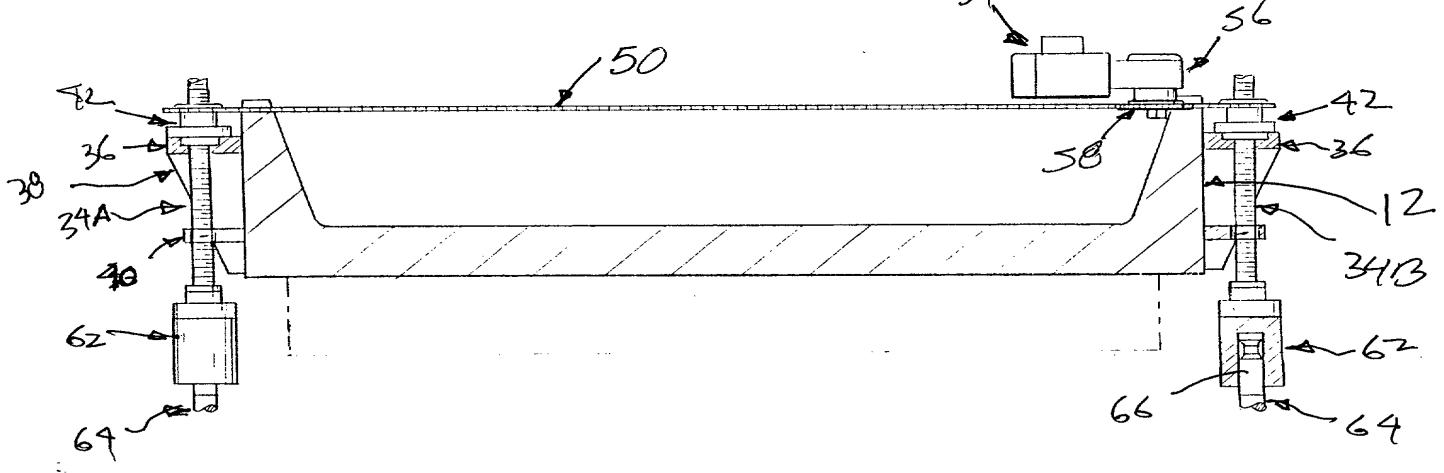


FIG-3



~~FIG - 6~~



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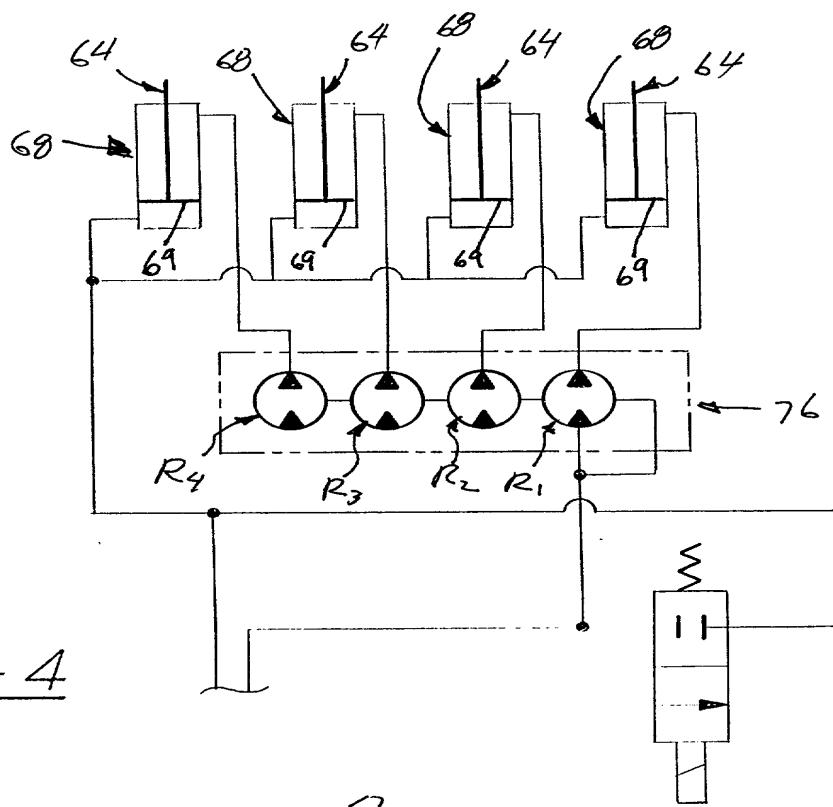


FIG - 4

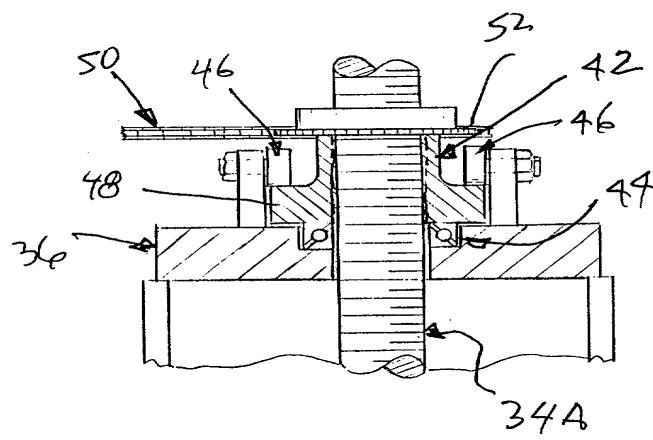
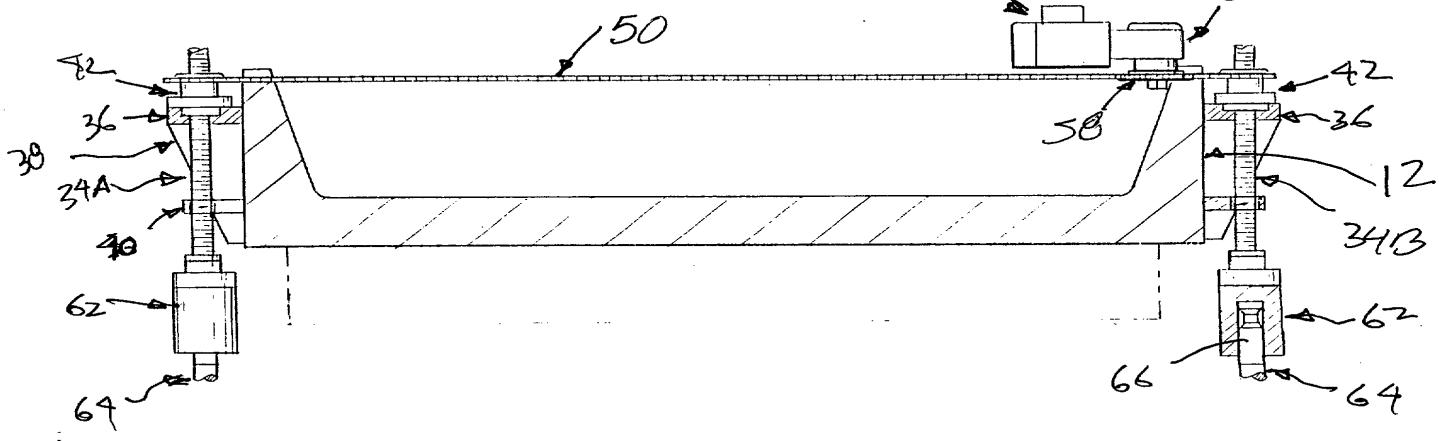


FIG - 6

FIG - 5



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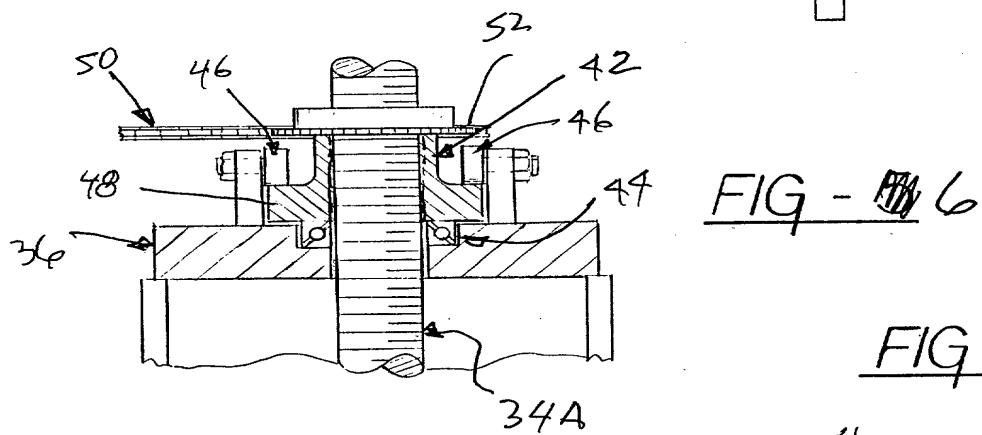
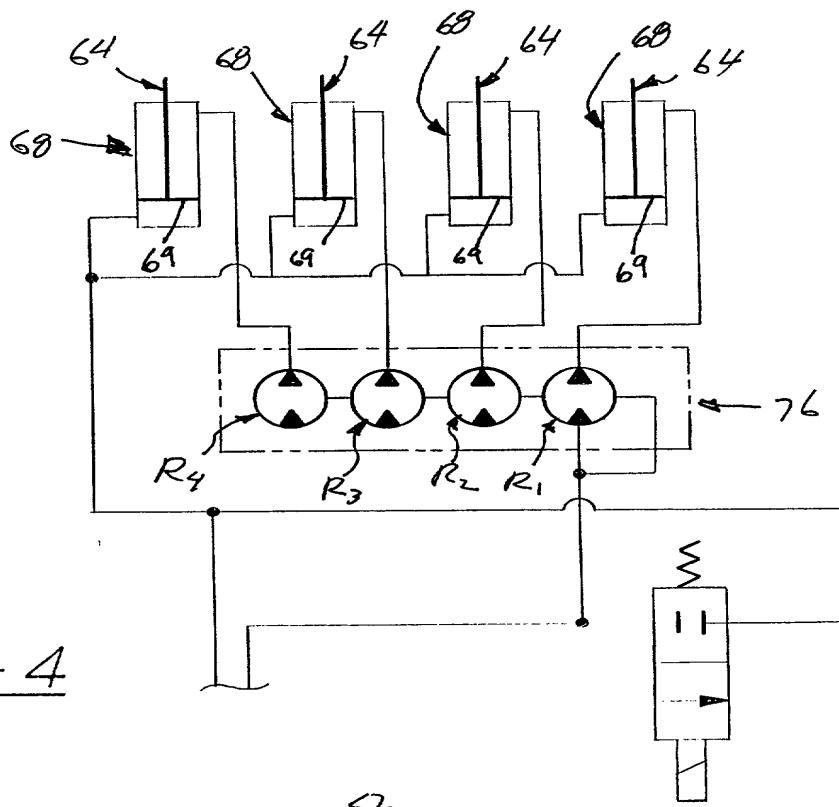


FIG - 5

